STANDARD OPERATING PROCEDURE NO. 12

SEDIMENT PROFILE IMAGING

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3.0 PURPOSE AND SCOPE

The purpose of this document is to define the standard operating procedures (SOP) for conducting sediment profile imaging (SPI) to aid in determining the biologically active zone (BAZ) within select geomorphic areas as part of the Newark Bay Study Area Remedial Investigation Work Plan (RIWP). This SOP provides descriptions of equipment, field procedures, laboratory procedures, and documentation necessary to conduct the survey. The objectives and locations of the SPI are discussed in the IWP.

This SOP may change depending on field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP shall be approved in advance by the Facility Coordinator (FC) (or Alternate FC) and the United States Environmental Protection Agency (USEPA) Remedial Project Manager. The actual procedure employed will be documented in the Newark Bay RI Report.

Other SOPs will be utilized in conjunction with this SOP, including:

- SOP No. 1 – Field Documentation;
- SOP No. 3 – Decontamination;
- SOP No. 5 – Positioning; and
- SOP No. 11 – Sediment Collection Using Grab Sampling Device.

4.0 PROCEDURES

4.1 EQUIPMENT LIST

The following equipment list contains materials which may be needed in carrying out the procedures contained in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- personal protective equipment (PPE) and other safety equipment, as required by RIWP Volume 3 (Tierra, 2005);
- navigation charts and Phase I SI Program BAZ and Core Locations figure (Figure 6-1 of the IWP);
- positioning equipment;
- winch;
- assorted nautical equipment (e.g., anchors, lines, personal flotation devices [PFDs]);
- permanent waterproof marker or grease pencil;
- marine VHF radio;
- vessel adequate for Newark Bay conditions;
- Sediment Profile Camera System;
- fathometer with a resolution of 0.1 foot;
- logbook; and
- data storage equipment (e.g., CD).

4.2 PROCEDURES

REMOTS (Remote Ecological Monitoring of the Seafloor) sediment profile imaging is a benthic sampling technique in which a specialized camera is used to obtain undisturbed, vertical cross-section photographs *(in situ* profile) of the upper 15 to 20 cm of the seafloor. This is a reconnaissance survey technique used for rapid collection and interpretation of physical and biological seafloor characteristics.

The Hulcher Sediment Profile Camera System is fitted with a digital camera and a strobe enclosed in a pressure-resistant housing. This housing is mounted in a sturdy aluminum box frame with a hydraulic arm to lower the prism and camera assembly at a 90-degree angle to the sediment. The camera is mounted on top of the prism and aimed down (vertically) at a mirror oriented at 45 degrees to the housing faceplate. The prism is filled with fresh water to prevent distortion of the faceplate in deep water and provide a clear water medium for capturing images. The digital camera is a Minolta Dimage7i that captures a 5.2 mega-pixel image, producing a 14.1 mega-pixel RGB image (JPEG format). The strobe illuminates the sediment allowing for operation in complete darkness and in turbid water. The aluminum frame allows deployment of the camera in relatively rough seas, as the frame will sit upright on the bottom as long as the downline is slackened when the frame touches the bottom.

The profile camera prism is also fitted with a digital video camera so that video and the digital still camera have the same view of the sediment profile. The video signal is sent to the surface via cable so that prism penetration can be monitored and an initial impression of benthic habitat type can be formed. The video signal will be recorded for future detailed evaluation and review.

SPI will be conducted at 14 locations within the Phase I Sediment Investigation (SI) Study Area. A minimum of two acceptable images will be collected at each location. A preliminary assessment will be made to determine if the images are of acceptable quality while on the sampling vessel. Any unacceptable stations will be resampled.

Three grab samples will be collected at each BAZ location in addition to SPI activities. The grab samples will be collected according to SOP No. 11 – Sediment Collection Using Grab Sampling Device.

4.3 SPI FIELD OPERATIONS

Prior to each field deployment, essential items will be gathered and tested for proper operation. The camera/prism system is mounted in a cradle that is secured to a larger frame that ensures that the prism penetrates the sediment at a 90-degree angle. A winch is used to lower the entire assembly (at a consistent rate) to the seafloor. When the system reaches the seabed the knife-like edge on the bottom of the prism, combined with the camera assembly and additional weights that are added, if necessary, based on the sediment conditions, allows the prism to cut a vertical slice into the sediments. The penetration rate of the camera/prism assembly into the sediment is controlled by a hydraulic piston. The camera can be triggered either by contact with the seabed or manually from the research vessel via the video cable. To permit proper penetration of the sediment by the prism, a brief time delay occurs between contact with the seafloor and the first exposure. The delay ranges from 1 second in soft mud to 15 seconds in hard sand. The camera can be set to take a series of images at about 1.5-second intervals during penetration or triggered multiple times from the surface. After the required number of exposures, including several exposures after full penetration, the camera assembly is retrieved to the ship or repositioned for additional images. The quality of the images can be monitored via the video link to the surface. Any unacceptable replicates are resampled in real time while still on station. On deck, the images are transferred from the microdrive in the camera to a computer and then to a CD for more permanent storage. The images are also reviewed in high resolution to ensure they are acceptable.

4.4 CALIBRATION PROCEDURES AND PREVENTATIVE MAINTENANCE

Prior to each field deployment, video components are tested for proper operation. Once the SPI system is assembled on board the research vessel, a system check is initiated that includes all features of the SPI system. In addition, before each field deployment, the clock in the SPI system will be set to match the clock used by the navigation system aboard the research vessel.

4.5 DECONTAMINATION

SPI equipment which has been immersed in Newark Bay sediments/waters will be decontaminated in accordance with SOP No. 3 - Decontamination.

4.6 IMAGE PROCESSING AND ANALYSIS

4.6.1 GENERAL APPROACH

Computer images will be analyzed using a Power Macintosh microcomputer and NIH Image, the National Institute of Health's image analysis program. Computer analysis procedures for each image are standardized by executing a series of macro commands. Data generated from each image analyzed are saved sequentially to an ASCII file for additional analysis and reduction using Microsoft Excel^{TM}.

The actual image analysis is done through a series of macro commands executed from a video screen menu. After each step, the analyst is asked if the results are satisfactory and given the chance to redo any step. During the image analysis session, two computer files are opened to receive data from each image. One file includes all computer-executed statements and the resultant data. This file is archived and can be accessed should any questions arise as to how the analysis of any particular image was conducted. A second file, that includes only the selected image data to be used in reports, is generated at the same time. After computer analysis, the images are put into the SPI photo archives for future reference.

4.6.2 SPECIFIC APPROACH

The following parameters are evaluated and documented for each location.

Prism penetration provides a geotechnical estimate of sediment compaction, with the profile camera prism acting as a dead weight penetrometer. The farther the prism enters into the sediment, the softer the sediment and likely the higher the water content. Penetration is measured simply as the distance the sediment moves up the length of the faceplate. If the weight of the camera frame is not changed during field image collection, then the prism penetration provides a means for assessing the relative sediment compaction between stations or different habitat types.

Surface relief is measured as the difference between the maximum and minimum distance the prism penetrates. This parameter provides an estimate of small-scale bed roughness, on the order of the prism faceplate width (16 cm). The causes of roughness often can be determined from a visual analysis of the images.

Apparent color redox potential discontinuity (RPD) layer is an important estimator of benthic habitat quality. It is the depth to which sediments are oxidized. The term "apparent" is used in describing this parameter because no actual measurement is made of the redox potential. An assumption is made that, given the complexities of iron and sulfate reduction-oxidation chemistry, reddish-brown sediment color tones are indications that the sediments are oxic (oxidized), or at least are not intensely reducing. This is in accordance with the classical concept of RPD depth, which associates it with sediment color. The depth of the apparent color RPD is defined as the area of all the pixels in the image discerned as being oxidized divided by the width of the digitized image. The area of the image with oxic sediment is obtained by digitally manipulating the image to enhance characteristics associated with oxic sediment (greenish-brown color tones). The enhanced area is then determined from a density slice of the image or, if image quality is poor, the area is delineated with the cursor.

Sediment grain size is a geotechnical feature of the sediment that is used to determine the type of sediment present. The nature of the physical forces acting on a habitat can be inferred from grain-size distribution of the sediments. The sediment type descriptors that are used follow the Wentworth classification as described in Folk (1974) and represent the major modal class for each layer identified in an image. Sediment grain size is determined by comparing the collected images with a set of standardized images taken of sediments for which mean grain size has been determined by laboratory analyses. Sediment grain sizes ranging from pebble/rock to gravel, sand, silt, and clay can be estimated accurately from the images.

Surface features include a variety of physical and biological features that can be seen at or on the sediment surface. These include SAV, worm tubes, fecal pellets, epibenthic organisms, bacterial mats, algal mats, shells, mud clasts, bed forms, feeding pits, and mounds. Each feature provides information on the type of habitat and its quality. Certain surface features are indicative of the overall nature of a habitat. For example, bed forms are always associated with physically dominated habitats; whereas, worm tubes or feeding pits are indicative of a more biologically accommodated habitat. Surface features are visually evaluated from each slide and compiled by type and frequency of occurrence.

Subsurface features include a variety of features such as burrows, water-filled voids, SAV rhizomes, infaunal organisms, gas voids, shell debris, detrital layers, and sediment lenses of different grain size. Subsurface features also reveal a great deal about the physical-biological control occurring in a habitat.

Successional stages of the fauna in a habitat can be estimated using SPI data. Characteristics that are associated with pioneering or colonizing (Stage I) assemblages, such as dense aggregations of small polychaete tubes at the surface and shallow apparent RPD layers, are seen in sediment profile images. Advanced or equilibrium (Stage III) assemblages also have characteristics that are seen in profile images, such as deep apparent RPD layers and subsurface feeding voids.

5.0 QUALITY ASSURANCE

The data quality objectives for the field collection of the SPI will be met by following several procedures. Proper assembly and operation of the SPI system will ensure that the digital still images obtained are clear and of high quality. Prior to each field deployment, SPI components are tested for proper operation. Once the SPI system is assembled on board the research vessel, a system check is initiated that includes all features of the SPI system. Proper system functioning (penetration of prism, flash from SPI camera) will be monitored with test images taken on deck.

To ensure that the required images are collected, the camera image counter will be checked to confirm that the system was functioning properly after every station or replicate deployment. Any mis-fires or improper camera operation will be corrected while on station. Almost any electronic or mechanical failure of the profile camera can be repaired in the field. Spare parts and a complete back-up camera will be carried on each SPI survey. Images will be collected at the required stations.

6.0 DOCUMENTATION

The documentation requirements for the field personnel will include recording observations made during SPI activities that could affect the quality of the data. Complete field documentation procedures are presented in SOP No. 1 – Field Documentation.

In addition, the following information will be recorded in a logbook (at a minimum):

- SPI location ID;
- Date;
- Time (EST);
- Profiling equipment (e.g., name and serial number);
- Equipment calibration information;
- Unusual conditions;
- Names of the members of the SPI/BAZ crew; and
- Number of SPI images attempted and collected.